III Equilibrium Real Exchange Rate Approach

The reduced-form equilibrium real exchange rate (ERER) approach to exchange rate assessment consists of three steps. First, panel regression techniques are used to estimate an equilibrium relationship between real exchange rates and a set of fundamentals. Second, equilibrium real exchange rates are computed as a function of the medium-term level of the fundamentals. Third, the magnitude of the exchange rate adjustment that would restore equilibrium is calculated directly as the difference between each country's actual real exchange rate and the equilibrium value identified in the second step.

Since 2003, the IMF's CGER assessments have used the ERER approach for 11 advanced economies. This section presents an updated methodology for estimating equilibrium real exchange rates for 48 countries over 1980–2004, which, as discussed below, also includes factors specific to emerging markets. For a more extensive presentation of the methodologies, see Ricci, Milesi-Ferretti, and Lee (2008).[18]

Theoretical Background and Variable Definitions

The literature on the determinants of real exchange rates is very extensive (see, for example, the surveys by Froot and Rogoff, 1995; Rogoff, 1996; and, for developing countries, Edwards, 1989; Hinkle and Montiel, 1999; and Edwards and Savastano, 2000).[19] Empirical analyses differ in the choice of underlying real exchange rate fundamentals, in part because of data availability considerations. In the econometric analysis of this section, the CPI-based real effective exchange rate, defined as the ratio of domestic consumer prices to a weighted index (exchange-rate-adjusted) of consumer prices in trading partners, is expected to depend on the following six fundamentals:[20]

- *Net foreign assets.* Standard intertemporal macroeconomic models predict that debtor countries will need a more depreciated real exchange rate to generate the trade surpluses necessary to service their external liabilities. Conversely, economies with relatively high NFA can "afford" more appreciated real exchange rates—and the associated trade deficits—while remaining solvent.[21] The stock of net foreign assets is scaled by each country's trade (the sum of exports and imports).
- *Productivity differential.* According to the so-called Balassa-Samuelson effect, if productivity in the tradables sector grows faster than in the nontradables sector, the resulting higher wages in the tradables sector will put upward pressure on wages in the nontradables sector, resulting in a higher relative price of nontradables (i.e., a real appreciation). The productivity differential used in the specification below is the difference in output per worker in tradables and nontradables production (relative to trading partners), and is expected to have a positive effect on the ERER.[22]
- *Commodity terms of trade.* Higher commodity terms of trade should appreciate the real exchange rate through real income or wealth effects.[23] The vari-

[18]The sample of countries is smaller than in Section II, owing to the difficulty in obtaining data for some determinants of real exchange rates, such as sector-level productivity measures. See Appendix 3.1 for the list of countries.

[19]For a recent application to the exchange rate assessment of Central and Eastern European countries, see Maeso-Fernandez, Osbat, and Schnatz (2004).

[20]Appendix 3.1 describes the construction of each variable and discusses some remaining limitations of the data.

[21]The net effect of investment income ensures that creditor countries would still run current account surpluses and debtor countries, current account deficits. The economic literature also refers to this long-standing issue as the "transfer problem." Previous analyses of the impact of the NFA position on the ERER include Faruqee (1995), who focused on the United States and Japan; Gagnon (1996), who used the cumulative current account as an approximation of net foreign assets; Bayoumi, Faruqee, and Lee (2005), who use trend net investment income; and Lane and Milesi-Ferretti (2002, 2004).

[22]This section uses new measures of productivity in tradables and nontradables, constructed on the basis of a six-sector classification of output and employment. For earlier studies using advanced-economy data, see Canzoneri, Cumby, and Diba (1999), Choudhri and Khan (2005), MacDonald and Ricci (2005, 2007), and Lee and Tang (2007).

[23]See, for example, Ostry (1988), Edwards and Ostry (1992), Ostry and Reinhart (1992), Chen and Rogoff (2003), and Cashin, Céspedes, and Sahay (2004).

able used below is a weighted average of the main commodity export prices (where country-specific weights reflect the share of particular commodities in a country's overall exports) divided by a weighted average of the main commodity import prices. All commodity prices are calculated relative to the price of manufacturing exports of advanced economies.

- *Government consumption*. Higher government consumption (as a ratio to GDP) is likely to appreciate the real exchange rate to the extent that such consumption falls more on nontradables than tradables, thereby raising the relative price of the former (Ostry, 1994; and De Gregorio, Giovannini, and Wolf, 1994).
- *Trade restriction index*. Trade restrictions may lead to higher domestic prices and more appreciated real exchange rates (Edwards and Ostry, 1990; Ostry, 1991; and Goldfajn and Valdes, 1999). The trade restriction index used below is a dummy variable that takes a value of 1 before liberalization and a value of 0 after liberalization, according to the liberalization years coded by Sachs and Warner (1995) and Wacziarg and Welch (2003).[24]
- *Price controls*. The share of administered prices in the consumer price index (CPI) basket is a proxy for the deviation of prices from their market value in transition economies. As price controls are removed, the rise in administered prices toward market levels—and hence the rise in the consumer price index—would tend to be accompanied by a real appreciation. A lower share of administered prices in the consumer price index is thus expected to be associated with a more appreciated real exchange rate in transition economies.

Estimation Results

The first column in Table 3 reports the estimated equilibrium long-run (cointegrating) relationship between the real exchange rate and the aforementioned set of explanatory variables, including a set of country-specific constant terms (the estimation methodology and robustness tests are described in Appendix 3.1).[25] The specification in column 2 also includes a parsimonious set of coefficients and dummy variables, which help control for country/region-specific factors or structural breaks (see Appendix 3.1 for details).

Table 3. Equilibrium Real Exchange Rate Approach: Regressions

	(1)	(2)
Net foreign assets	0.04***	0.04***
Productivity differential		
All countries	0.19***	0.12*
Central and Eastern European countries	…	1.30***
Commodity terms of trade	0.55***	0.39***
Government consumption	2.91***	2.65***
Trade restriction index	0.12***	0.14***
Price controls	–0.04**	–0.02
Observations	861	861
Adjusted R^2	0.6	0.62

Note: Column (2) includes a parsimonious set of coefficients and dummy variables, which help control for country/region-specific factors or structural breaks (see Appendix 3.1 for details). *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively, based on standard errors robust to serial correlation.

- The estimated coefficient on the net foreign asset variable scaled by trade is about 0.04. A deterioration of the ratio of net foreign assets to trade of about 50 percentage points (as experienced by the United States between 2001 and 2005) would imply a depreciation of the equilibrium exchange rate by about 2 percent.
- A 10 percent increase in the domestic productivity of tradables relative to nontradables (relative to the corresponding variable for trading partner countries) tends to appreciate a country's equilibrium exchange rate by about 1 to 2 percent in most countries, and up to 13 percent in Central and Eastern European countries.[26]
- A 10 percent increase in the commodity terms of trade implies an equilibrium appreciation of about 4 to 6 percent. As an example, between 2001 and 2005 Venezuela's terms of trade improved by about 50 percent, implying an appreciation in its equilibrium real effective exchange rate of about 20 to 30 percent.
- An increase in the government consumption to GDP ratio of 1 percentage point is associated with an appreciation of the equilibrium real exchange rate of 2½ to 3 percent.

[24]The limitation of the trade restriction index is its inability to capture gradual liberalization. Other studies have used trade openness (average export and import share of GDP). Such a measure, however, is only an indirect indicator of the extent of liberalization and is subject to endogeneity when used in exchange rate regressions (as a change in the exchange rate would affect openness for a given trade regime).

[25]Country-specific constant terms are needed because (1) there could be residual country-specific effects that are not captured by the other regressors; and (2) the real exchange rates are index numbers with no natural common anchor across different countries.

[26]The estimated effect for the whole sample is smaller than the amount predicted by theory (which is equal to the share of nontradables in the CPI), but is in line with recent estimates for a large sample of advanced and developing countries (Choudhri and Khan, 2005, estimate a coefficient of about 0.2).

- A move to a liberalized trade regime, as in the example of Brazil around 1990, would depreciate the equilibrium real exchange rate by 12.14 percent.
- The elimination of administered prices in 7 percent of the price basket (one unit of the index on the share of administrative prices) is associated with an appreciation of the real exchange rate by about 2 to 4 percent. As an example, the Slovak Republic experienced a liberalization of prices accounting for about 20 percent of the price basket between 1997 and 2004, which would be associated with an equilibrium appreciation of the real exchange rate of about 6 to 12 percent.

Equilibrium Real Exchange Rates

Equilibrium real exchange rates are computed by evaluating the relationship between the real exchange rate and the fundamentals at an appropriate level of those fundamentals. The ERER approach computes twosets of equilibrium real exchange rates based, respectively, on the current value of fundamentals and their projected medium-term value (WEO projections).[27]

Equilibrium real exchange rates also reflect the estimated value of the country-specific constants, which are equal to the average of each country's real exchange rate over the sample period. Whenever the sample period is short, as in the case of the Central and Eastern European countries, or there is a "peso problem" (i.e., systematic overvaluation or undervaluation for a prolonged period of time), caution is warranted in interpreting the estimates of the country-specific constants as the average value anchoring each country's equilibrium real exchange rate.

Exchange Rate Assessments

The magnitude of the exchange rate adjustment that would restore equilibrium is calculated directly as the difference between each country's current real exchange rate and two possible equilibrium values, corresponding to current or medium-term fundamentals. A final step in the ERER approach—like in the MB approach—is to impose multilateral consistency of the estimated exchange rate adjustments by applying a common correction factor, as explained in Section II.

The ERER approach does not yield in and of itself any indication of how quickly the exchange rate would adjust to restore equilibrium. To gain some insight into this issue, the long-run model was estimated with an error-correction specification. The results suggest that, on average, two and a half years are enough to halve the gap between actual and equilibrium exchange rates for both advanced and emerging economies (or, equivalently, the gap closes by about one-fourth within a year).

While the econometric model captures the broad trends in real exchange rate behavior, estimates of equilibrium real exchange rates are unavoidably subject to significant uncertainty. In particular, the forecast standard error of the real exchange rate is about 12 percent, which is reduced to 7–8 percent if one accounts for factors driving the real exchange rate in the short run through an error-correction specification.

Appendix 3.1. ERER Approach: Data and Methodology

Data Description

The sample includes 48 countries for the period 1980 to 2004. From the 54 countries used in the MB approach, the following six countries were excluded from the ERER approach owing to data availability: Algeria, Croatia, Egypt, Israel, Luxembourg, and Tunisia. This subsection describes in detail the construction of the variables used in the ERER approach.

- *Real effective exchange rate* is based on consumer price index (CPI) and new competitiveness weights constructed from 1999–2001 data (Bayoumi, Lee, and Jayanthi, 2006). The nominal exchange rate and CPI were obtained from IFS, and the euro area aggregate exchange rate (prior to 1999) was obtained from the European Central Bank.
- *Productivity of tradables and nontradables relative to trading partners.* Productivity, measured as output per worker, is calculated on the basis of a newly constructed data set for output and employment for a six-sector classification (or three-sector when the six-sector data were not available). In the six-sector classification, the tradable sector includes agriculture, hunting, forestry, and fishing; mining, manufacturing, and utilities; and transport, storage, and communication, whereas the nontradable sector includes construction; wholesale and retail trade; and other services. In the three-sector classification, the tradable sector includes agriculture and industry. The sources are the United Nations Statistics Division, International Labor Office Bureau of Statistics, Eurostat, World Bank, Groningen Growth and Devel-

[27]Net foreign assets are extended by cumulating the projected WEO current accounts. Productivity variables, the trade liberalization index, and the share of administered prices are left unchanged at the latest available observation. An alternative way to calculate the equilibrium exchange rate would be to apply the econometric methodology suggested by Gonzalo and Granger (1995), decomposing fundamentals into a permanent and transitory component and using the permanent component to calculate the ERER.

opment Centre, CEIC database, IMF country desks, and national authorities.[28]

A few missing observations were filled using the sectoral shares for adjacent years and aggregate data. Series for trading partners were constructed by applying the competitiveness weights to productivity series that were extended when data were missing for a few early or late years (using the trends over the adjacent three-year period). Robustness checks were undertaken using relative productivity measures that either exclude the volatile agricultural sector for some countries (Chile, Colombia, Morocco, Peru, South Africa, Turkey, Poland, Thailand, Malaysia, Mexico, and New Zealand) or are constructed from employment series smoothed with a Hodrick-Prescott filter.

- *Commodity-based terms of trade* is the ratio of a weighted average price of the main commodity exports to a weighted average price of the main commodity imports. The index is constructed from the prices of six commodity categories (food, fuels, agricultural raw materials, metals, gold, and beverages), measured against the manufacturing unit value index (MUV) of the IMF's *World Economic Outlook*. These relative commodity prices of six categories are weighted by the time average (over 1980–2001) of export and import shares of each commodity category in total trade (exports and imports of goods and services). The terms of trade index is the ratio of aggregate indexes of commodity exports and imports, as follows:

$$TOT_j = \prod_i (P_i/MUV)^{X_j^i} / \prod_i (P_i/MUV)^{M_j^i},$$

where i represents the six commodity categories; X_j^i is the share of exports of commodity i in country j's total trade, averaged over 1980–2001; and M_j^i is the share of imports of commodity i in country j's total trade, averaged over 1980–2001.

The prices (P_i) of the six commodity categories are obtained from the database of the RES Commodities Unit. Exports and imports by commodity category are obtained from the United Nations Common Format for Transient Data Exchange (COMTRADE) data at SITC two-digit level; South Africa's gold export series is obtained from national sources.

Trade data are obtained from the IFS and extended using WEO data. Pre-1998 merchandise trade for the euro area are constructed on the basis of COMTRADE data.[29] Singapore's exports are adjusted for re-exports.

- *Net foreign assets to trade* is the ratio of net foreign assets at the end of the previous period to the average exports and imports (in goods and nonfactor services) of the previous period. The net foreign asset data are from Lane and Milesi-Ferretti (2007b).
- *Government consumption–to-GDP ratio* is defined as the ratio of government consumption (purchases of goods and services plus government wages) to GDP. The main source is OECD, Annual National Income Accounts, and missing observations are spliced using the IFS or WEO data.
- *Trade restriction index* takes the value of 0 during years of liberalization and 1 during years of restriction. It is constructed on the basis of the liberalization years suggested by Sachs and Warner (1995), and extended for recent years by Wacziarg and Welch (2003).
- *Share of administered prices* (for transition economies only) is constructed by the EBRD as the number of categories with administered prices out of a basket of 15 categories (EBRD, 2005). Hence a unit increase in this variable corresponds to an increase in the share of administered prices corresponding to about 7 percent of the CPI basket. This variable is available for the Czech Republic, Hungary, Poland, Russia, Slovak Republic, and Slovenia, and takes a value of 0 for the other countries.
- *Additional terms in Table 3 regressions*. The regression in column 2 includes coefficients and dummy variables that help control for several country/region-specific factors or structural breaks. In particular, it includes four additional dummies to account for significant breaks in the real exchange rate series that are not captured in the Sachs and Warner index as episodes of major liberalization: three dummies (equal to 1 before 1986 and 0 otherwise) for Indonesia, Malaysia, and Thailand; and one dummy (equal to 1 in 1991–2001 and 0 otherwise) for Argentina. It also allows for an heterogeneous slope for China for the Balassa-Samuelson effect (with an estimated coefficient of about 0.5). Finally, the government spending variable is dropped for Central and Eastern European countries. The regression in column 1 accounts only for the 1982 devaluation in Indonesia (associated with import liberalization) and for the Argentina dummy.

[28]Our classification follows De Gregorio, Giovannini, and Wolf (1994) and is bound to be imperfect. As the authors acknowledge, every sector has some degree of tradability, which can vary from country to country.

[29]For the euro area prior to 1998, member-country data (which includes intra–euro area trade) is aggregated first; and then area-wide services exports and imports are calculated by assuming that the trade in services outside the euro area is 10 percentage points higher than the trade in goods outside the euro area. The 10 percentage point difference between trade in goods and services is based on observations from 1998 onward, the only period where data is available for services trade both within and outside the euro area.

The set of real exchange rate fundamentals of this analysis is broader than that used in previous studies, and includes novel measures of productivity differentials and net foreign assets. Nevertheless, most variables capture the underlying economic effect only imperfectly. For example, the split between tradable and nontradable sectors is bound to be arbitrary to some extent. Similarly, the net external position is the appropriate measure of the "transfer problem" only to the extent that rates of return on external assets and liabilities are broadly the same (Lane and Milesi-Ferretti, 2002). Finally, commodity terms of trade are calculated for a given (fixed) composition of a country's exports and imports, which is likely to have changed during the sample period. However, data availability issues prevent us from addressing some of these concerns. For example, while interest payments on net foreign assets are available, the appropriate measure of the "transfer effect" requires the calculation of rates of return (which include capital gains and losses). These calculations are fraught with measurement problems, especially for the early years of the sample.

Econometric Methodology

This appendix describes the estimation of the long-run relationship between the real effective exchange rate and macroeconomic fundamentals. Given the limited length of the sample (25 years), estimating separate real exchange rate equations for each country gives very imprecise results. This shortcoming can be reduced by pooling the data. Over the sample period the variables exhibit unit root behavior, when tested via the Levin, Lin, and Chu (2002) and Im, Pesaran, and Shin (2003) panel unit root tests. We find evidence of panel cointegration among our variables using the Kao (1999) test—there appears to be a long-run relationship between the real effective exchange rate and the set of fundamentals.[30]

The estimation is thus undertaken using the dynamic ordinary least squares (DOLS) methodology developed by Stock and Watson (1993), applied to a panel of countries with fixed country effects. Fixed effects are necessary because the real effective exchange rate measures are index numbers, making their levels not comparable across countries. They also account for time-invariant country-specific factors, thus reducing the omitted variable bias. The DOLS methodology has been widely used in panel analysis with nonstationary data. The results were also checked with an alternative panel cointegration estimation procedure (FMOLS; see Kao and Chiang, 2000; Pedroni, 2000; and Phillips and Hansen, 1990) and results were similar.[31]

The estimated cointegrating relationship is imposed in an error-correction formulation, to assess the speed of adjustment of the real exchange rate toward its long-run equilibrium relation. The long-run relationship should be interpreted as an equilibrium relationship rather than a causal one. One might expect the presence of reverse causality, particularly between the real exchange rate and the productivity or the net foreign asset indicators.

The forecast standard error of the real exchange rate is estimated at about 12 percent (mostly due to the standard error of the regression at about 11 percent, hence with little variation across countries and years). This is mainly because the real exchange rate estimation is tailored to capturing the long-run relationship between the real exchange rate and the fundamentals and neglects short term exchange rate dynamics, which are notoriously volatile. If one accounts for short-term effects, for example when imposing the cointegrating vector in an error-correction mechanism, the forecast standard error of the real exchange rate is estimated at about 7–8 percent.

Several robustness tests were performed and yielded similar estimation results. First, alternative series were employed for the net foreign assets ratio (to GDP, to imports, and to exports), the relative productivity measures (see the data description subsection in this appendix), and the government consumption ratio (from IFS rather than OECD). Second, OLS regressions were performed on three-year averages of the data. Third, different slopes of the relative productivity variable were allowed during crisis times (as defined by a 20 percent depreciation): the coefficient during crisis times were larger, but the coefficients during noncrisis times were overall unaffected.

[30]The programs adopted for testing for panel unit root (STATA routines) and for panel cointegration (NPT1.3 in www.maxwell.syr.edu/maxpages/faculty/cdkao/working/npt.html) require a balanced panel; hence some countries and years are dropped from the sample for these tests. A panel unit root was not rejected for the commodity price index. However, a Phillips-Perron unit root test run on commodity prices for each country separately could not be rejected for the vast majority of countries. Considering the limitation of the panel unit root test in dealing with cross-sectional dependence, which is likely to be very strong for commodity prices, we ignore the panel unit root test results and treat commodity prices as nonstationary.

[31]Plain fixed-effects estimation provides consistent estimates if the residuals are stationary. However, it would generate incorrectly lower standard errors—and misleading inference—if the residuals are correlated with the stationary component of the unit root processes of the explanatory variables, which is generally the case. The dynamic OLS methodology adds leads and lags of first differences of right-hand-side variables to the set of regressors in order to wipe out such correlation (we employ one lead and lag, but we also explore robustness to more leads and lags). As this automatically introduces serial correlation of the residuals, which distorts standard errors, an additional correction is necessary (we use the Newey-West method). The DOLS residuals were found to be stationary using the aforementioned panel unit root tests, a result which is consistent with panel cointegration. The FMOLS panel cointegration estimation based on the routine provided by Kao and Chiang (2000) was used mainly as a robustness exercise as it requires a balance panel like the panel unit root and panel cointegration tests.